Event Report

FHWA Office of Bridges and Structures

Subject: Ft. Pitt Tunnel Luminaire Connection Failure				
Date of Event: September 30, 2012		**Location:** Pittsburgh, PA		
Discipline:	Structural Design	Structural Inspection	Geotech	Hydraulic
Distributed for your:	Information		Action	
Audience:	For Internal Use		Public	

Relevant Policy or Guidance: None.

Summary: The Ft. Pitt Tunnel carries I-376 through Mt. Washington between downtown Pittsburgh and its west end. On September 30, 2012 an overhead luminaire (lighting fixture) fell from its support bracket onto a parking apron within the portal of the tunnel on the downtown side. The connection failed as a result of galvanic corrosion between the aluminum frame of the luminaire and the stainless steel bolts connecting it to the support bracket. The fixture was manufactured by Schréder Lighting.

Galvanic corrosion is an electrochemical process that can occur between dissimilar metals. During this process, metallic ions sacrificially move from the less noble metal (smaller atomic number) to the more noble metal which accelerates the deterioration of the less noble metal while retarding the deterioration of the more noble metal.

This incident is very similar to one that occurred in Boston's Central Artery/Tunnel in March of 2011. The results of that investigation were circulated by the Office of Bridge Technology and are attached to this Event Report for your reference.

Current Report [October 25, 2012]: A luminaire similar to the one that fell is shown in Figure 1. The luminaires are approximately 49-inches long and weigh 75 lbs. Like the one that fell, the fixture shown is mounted to the ceiling of the tunnel over an area used by maintenance workers and tunnel operators to park their vehicles just inside one of the tunnel portals. However, a large majority of the 1374 luminaires in the eastbound and westbound bores of the Ft. Pitt Tunnel are wall mounted.

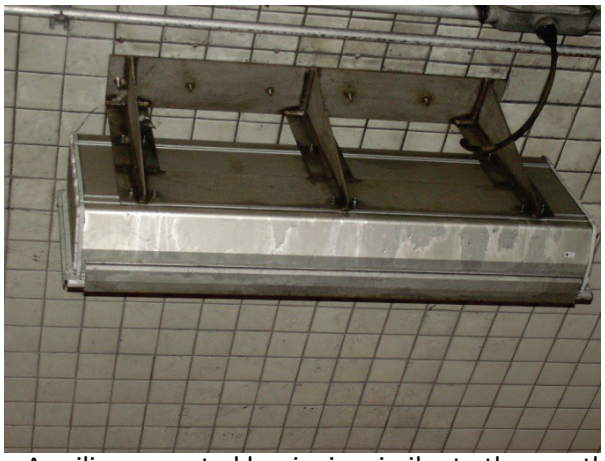

Figure 1. A ceiling mounted luminaire similar to the one that fell.

Whether ceiling mounted or wall mounted the connection between the luminaire and the supporting stainless steel brackets is made by sliding both an upper and lower flanged aluminum channel in the back of the luminaires over the heads of 12 stainless steel bolts. Nuts on the bolts are tightened to

clamp the flanges of the aluminum channel against the stainless steel bracket by the heads of the bolts. Figure 2 shows a detail of the wall mounted luminaire. The view in Figure 3 is an enlarged portion of the detail included in Figure 2. Figure 3 shows the position of the stainless steel bolt (shaded in blue), the head of which is in the upper aluminum channel (hashed in yellow), and the shank of which passes through the upper stainless steel mounting bracket. The flanges of the aluminum channel are not shown on this detail.

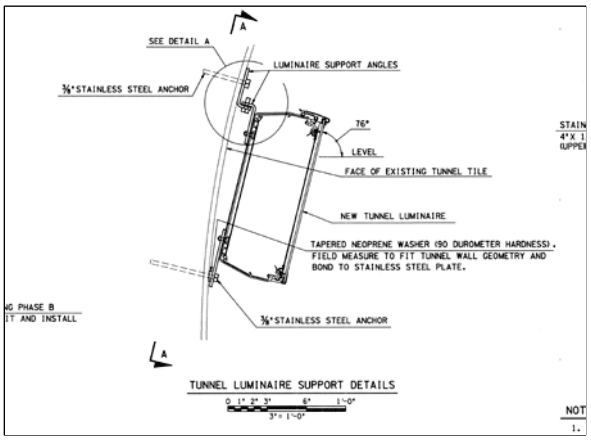

Figure 2. Wall Mounted Luminaire Detail.

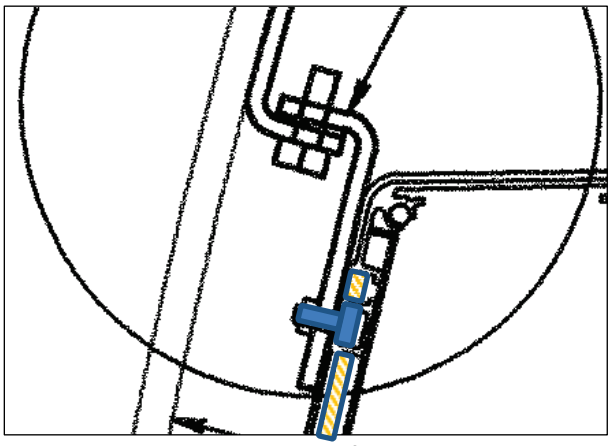

Figure 3. Enlarged Detail of the Connection.

Figure 4 shows the back of a typical luminaire that was removed from its mounting brackets so that the connections could be inspected. The flanged channels which run longitudinally near the outside of the luminaire along its back are visible as well as the (shiny) efflorescence from galvanic corrosion where the stainless steel brackets were attached with the stainless steel bolts. Figure 5 shows an enlargement of the stainless steel bolt head slotted in one of the aluminum flanged channels.

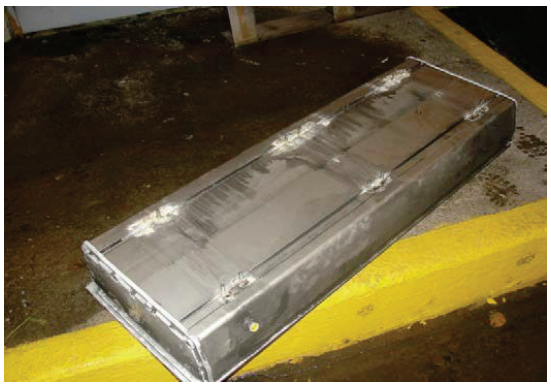

Figure 4. Back of typical luminaire.

Figure 5. Bolt head in aluminum channel.

PennDOT immediately responded to the fall of the luminaire by disconnecting others in the same area and inspecting their connections. All of the luminaires inspected in the vicinity exhibited signs of corrosion with the deterioration of the connections rated from minor to advanced by inspectors based on a visual assessment of the amount of section loss from the aluminum flange. As a result of this limited investigation PennDOT formulated and implemented a plan of action to insure the safety of motorists using the Ft. Pitt Tunnel.

The PennDOT plan reflects a considered approach that effectively insured safety while efficiently

leveraging resources and minimizing impact on the traveling public. Knowing that galvanic corrosion can be accelerated in the presence of an electrolyte solution of moisture and chlorides, PennDOT disconnected and inspected the connections of luminaires adjacent to sources of moisture in the tunnel and in particular near the tunnel portals, where moisture and road salt are combined and circulated by the turbulence of traffic entering and exiting the tunnel, and near areas of water leakage within the tunnel. As the process of disconnecting, inspecting and reinstalling a luminaire proved very time consuming, in areas away from sources of moisture, PennDOT used a dead load to proof test the integrity of the luminaire connections.

For the proof test, a dead load equal to the weight of a luminaire was suspended from each luminaire to essentially establish a minimum factor of safety of 2 for the capacity for the connection. The dead load was applied incrementally using 2 buckets full of sand each weighing 37.5 lbs. After establishing confidence in the process by load testing followed by removal of the luminaire and inspection of the aluminum flanges, PennDOT used load testing solely to confirm the integrity of 622 fixtures.

Figure 6 shows a close up of the flanged aluminum channel on the back of the luminaire that fell. The locations where two of the bolt heads pulled through the deteriorated flanges are indicated by the red ovals. As the lighting fixtures were originally installed in 2002 this level of deterioration was the result of 10 years of exposure.

Figure 6. Close up of back of luminaire that fell showing deteriorate aluminum flanges

Although 4 luminaires inspected were found to have advanced states of corrosion, none of those 4 exhibited the same level of deterioration as the one that fell. Regardless, to insure the long-term viability of these lighting fixtures, once it is developed, PennDOT will be deploying a permanent retrofit to insure the electrical isolation of the dissimilar metals used in the connection. It is currently expected that this retrofit will be in place by the end 2012.

In addition, these same luminaires with similar mounting details were installed in PennDOT's Liberty Tunnel in 2010 and were intended to be installed in the Squirrel Hill Tunnel this year. As a result of this incident, the luminaires near the portals of the Liberty Tunnel were inspected and, after only trace levels of oxidation were found, additional inspections were deemed unnecessary. The installation of the luminaires in the Squirrel Hill Tunnel has been delayed until a permanent retrofit is developed.

Previous Reports: None.

FHWA Response: At this time, FHWA is providing support to the investigation through the Division

Office. In addition to the immediate support FHWA is providing to the ongoing investigation and near-future retrofit, FHWA will be working with PennDOT and the luminaire manufacturer to identify where their fixtures and similar products have been used in other tunnels or transportation structures. Once projects have been identified FHWA will provide that information to the appropriate owners. However, transportation structure owners need to be aware that this problem can occur in luminaires produced by other manufactures (as was the case in Boston described in the attached email message) and in similar products or applications if dissimilar metals are used in the connections.

Attachments: Attached please find a copy of the email message distributed by the Office of Bridge Technology in response to the findings of the similar incident that occurred in Boston's Central Artery/Tunnel.

For further information contact:

- Joey Hartmann, Office of Bridges and Structures; (202)366-4599.
- Derek Constable, PA Division Office; (717)221-4542.

Attachment

From: Lwin, Myint (FHWA)
Sent: Friday, March 25, 2011 5:03 PM
To: Maruri, Rodolfo (FHWA); Byer, Daniel (FHWA); Greer, Matt (FHWA); O'Shea, Dennis (FHWA)
Cc: BRIDGE_ALL
Subject: Tunnel Ceiling Lighting Fixtures
Attachments: Luminaire Detail.pptx; c20b2_380_cde322_4.TIF

Greetings, Folks: By now you may have heard or read from the Associated Press on March 16, 2011 that one of the approximately 23,000 tunnel ceiling lighting fixtures fell on I-93 of the BIG DIG on February 8. Fortunately, no one was hurt. Jesus Rohena, Raj Ailaney and I went up to Boston yesterday to support the MADivision Office in meeting with the MassDOT to learn more about the failure.

The lighting fixture is as shown in the attached sketches and manufactured by NuArt Manufacturing Inc. The wireway is an 8' 2 ½" long by 9 ¾" wide aluminum extrusion with powder coating and continuous lips on both sides where the stainless steel latches are attached to hold the lighting fixtures in place. 10 latches (5 on each side) are used to hold each 8' 2 ½" fixture.

The metallurgical analysis of the fallen fixture revealed that significant corrosion of the lips at the locations where stainless steel clips were attached to the lips. Complete thickness of the lips was consumed by corrosion, allowing the lighting fixture to fall off from the wireway. The lighting fixture weighed about 100 pounds. Corrosion was observed in other areas along the lips, but to a lesser degree. The analysis also concluded that the corrosion was caused by (1) an aggressive chloride environment, (2) crevice corrosion at crevices created by the clamping force exerted on the aluminum lips, and (3) galvanic corrosion caused by two dissimilar metals when the coating was breached and crevices formed. The analysis further concluded that the primary cause of failure is the corrosion of the aluminum lips at tight crevices, and the galvanic corrosion played a secondary role.

As an urgent and temporary measure, the MassDOT has been performing nightly inspection to check for corrosion along the aluminum lips, and between the SS latches and aluminum lips. In areas of severe corrosion, the latches were loosened and moved a small distance to a non-corroded area of the lips. Using this method, the State was taking care of the fixtures near or over a traveled lane first. As of yesterday, MassDOT has inspected 96% of the 23,000 tunnel lighting fixtures. It is estimated that about 1.5% of the fixtures have significant corrosion problems. Most of the problems are near the portals. Inspection, analysis and solution-finding activities are ongoing.

MassDOT provided us information that the follow tunnels also have lighting fixtures manufactured by NuArt:

Tunnel	City, State	Wireway	Finish	Hardware

		Material		
Chesapeake Bay Bridge, Tunnel District	Virginia Beach to Northampton, VA	Aluminum	Anodized /Painted	Stainless
Brooklyn Battery Tunnel	New York, NY	Aluminum	Painted	Stainless
Eisenhower Johnson Memorial Tunnels	Dillon, CO	Aluminum	Painted	Stainless
Hampton Roads, I-664	MD	Aluminum	Anodized	Stainless
Ft McHenry Tunnel	MD	Aluminum	Anodized	Stainless
Baltimore Harbor Tunnel	MD	Aluminum	Anodized	Stainless

I am sending this for your information in working with the States to determine if they have experienced similar corrosion problems. If any of you are aware of other tunnels that have NuArt lighting fixtures, please let me know. Thank you. If you have any questions, please let me know.

Following is a news clipping for your information.

Mass. to review lighting in Big Dig tunnels

The Associated Press
Posted: 03/16/2011 02:35:23 PM PDT
Updated: 03/16/2011 06:06:03 PM PDT

BOSTON—State transportation officials have discovered corrosion in some of the lighting fixtures throughout Boston's Big Dig tunnel system after one of the 110-pound fixtures crashed onto the road in early February, missing cars traveling below.

No one was injured.

Transportation Secretary Jeffrey Mullan said workers have inspected 95 percent of the 23,000 light fixtures, including all the fixtures located over roadways. He said some corrosion was detected in less than 2 percent of the fixtures, and there's no danger to the public.

"This is a relatively isolated incident, but it's something that we're taking very seriously," Mullan told reporters Wednesday. "The tunnels remain safe."

Mullan said the fixture is the first lighting element to fall since the $15 billion network of tunnels, bridges and roadways transformed downtown Boston. The project officially came to an end in 2007.

Mullan said the state has notified the Federal Highway Administration about the problem and has contacted the manufacturer of the fixtures, NuArt Lighting in Fullerton, Calif.

A call to NuArt Lighting was not immediately returned.

The Big Dig was the most expensive highway project in U.S. history, prompted criticism of pork barrel spending, and was plagued by cost overruns and design problems, including leaks.

The most serious incident occurred in July 2006, when several 4,600-pound ceiling panels in another portion of the tunnel system

Have a great weekend!

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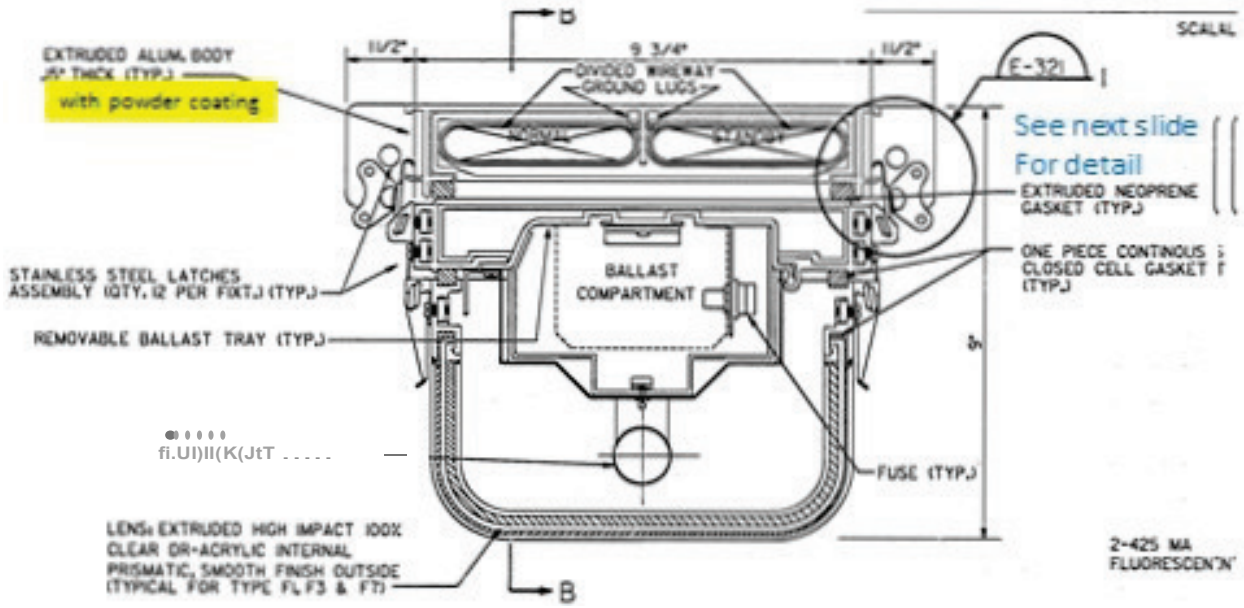
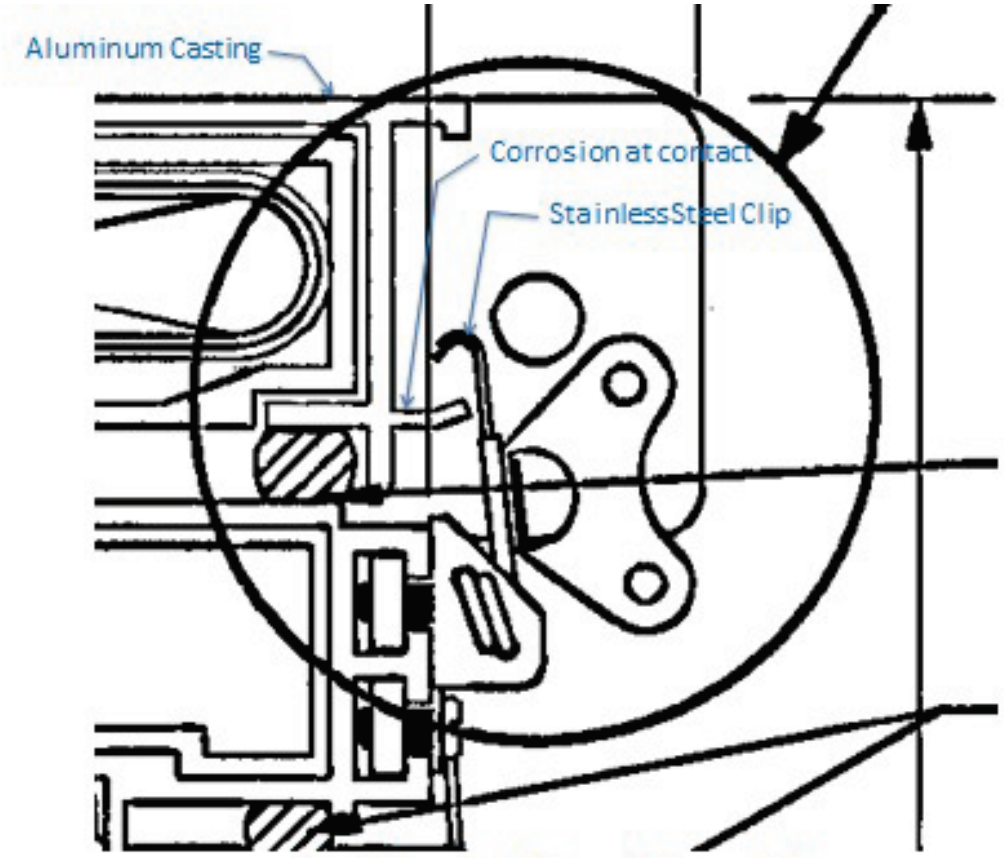
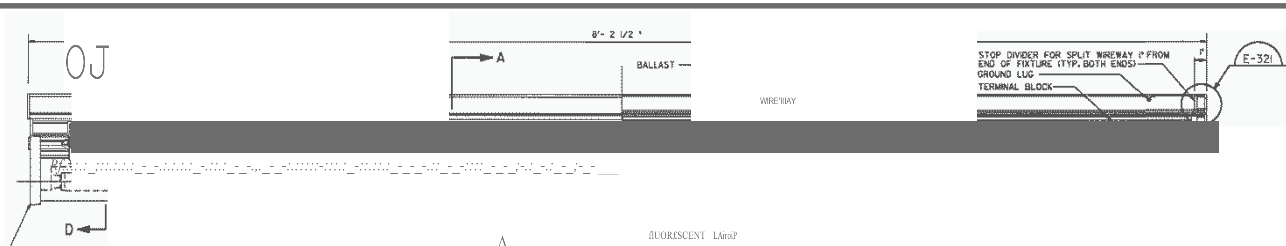


TYPE F1 FIXTURE – SECTION A



Stainless Steel Latch Assembly

BOSTON INTERSTATE I-90 /I-93					
F.H.W.A. REGION NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
1	MASS	I-93-1(087)	1998	380	1870



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TYPES F1, F3 & F7 - TUNNEL LIGHTING FIXTURE DETAIL

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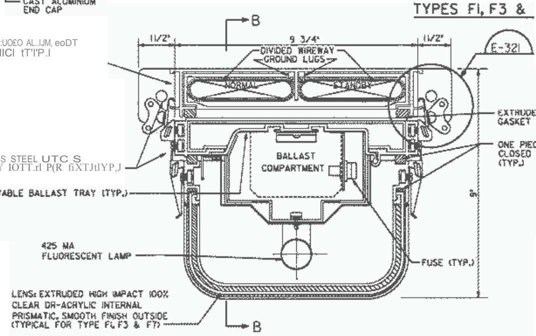

B
11/2"
9 3/4"
11/2"
E-321
DIVIDED WIREWAY
GROUND LUGS
NORMAL
STANDBY
EXTRUDED NEOPRENE GASKET (TYP.)
ONE PIECE CONTINOUS CLOSED CELL GASKET (TYP.)
BALLAST COMPARTMENT
REMOVABLE BALLAST TRAY (TYP.)
425 MA FLUORESCENT LAMP
FUSE (TYP.)
LENS: EXTRUDED HIGH IMPACT 100% CLEAR DR-ACRYLIC INTERNAL PRISMATIC, SMOOTH FINISH OUTSIDE (TYPICAL FOR TYPE F1, F3 & F7)

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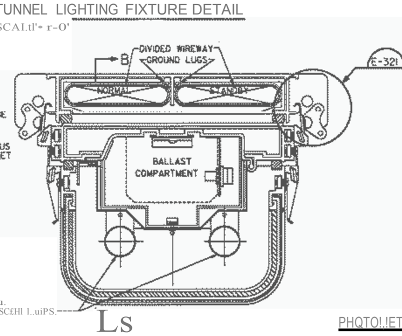
TYPE F1 FIXTURE - SECTION A

SCALE: 6" = 1'-0"



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TYPE F3 FIXTURE - SECTION A

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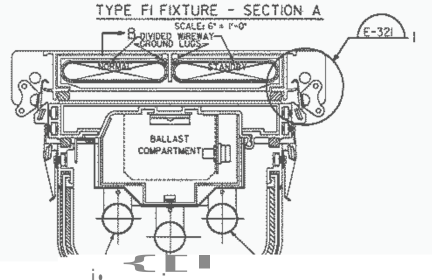


1500 MA FLUORESCENT LAMP

B

425 MA FLUORESCENT LAMP

SCEI<I;T IAWP

TYPE F7 FIXTURE - SECTION A

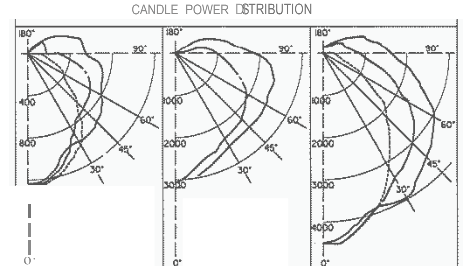
SCALE: 6" = 1'-0"

LATCH RUMIER

SECTION O - LATCH RETAINER

PHOTO!.IETRIC !SEY

CANDLE POWER DISTRIBUTION



fiXT IYP£1'- 1-425MA LAMP,75 WATTS

f'XTUIlE n'PE-FS 2-u5WA Lu.IP'S. 75 WATTS

rom.REtI'T'tn LA.MP,75WATTS.

FLUORESCENT TUNNEL LIGHTING FIXTURE PHOTOMETRIC DATA

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ALL PLAN REFERENCES TO FUTURE WORK HAVE BEEN COMPLETED UNLESS OTHERWISE NOTED

RECORD DRAWING

0 ½ 1 1½ FEET

3" = 1'-0"

REV	DATE	BY	SUB	APP	DESCRIPTION
4	14 MAR 06	MEV		AXG	INCORPORATED FIELD CONDITIONS
3	14 MAR 06	MEV		AXG	NOTE ADDED
2	17NOV98	DJB	KMM	GWK	MODIFY AND ADD DETAILS
1	14OCT98	CAB	KMM	GWK	GENERAL REVISIONS

DESIGNED BY D. A. LANG
DRAWN BY D. A. LANG
CHECKED BY A. PIZZANO
IN CHARGE G. KILE
DATE 05 JUN 98

MASSACHUSETTS HIGHWAY DEPARTMENT

Central Artery (I-93)/Tunnel (I-90) Project

I-90 / I-93
ELECTRICAL GENERAL CONTRACTOR
TUNNEL LIGHTING FIXTURE
FLUORESCENT

SCALE: AS NOTED
CONTRACT NO. C20B2
DRAWING NO. C20B2-E-322
REV. 4